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Controlling Protein Level of Meal Production at Cottonseed Oil Mills

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Joseph G. Knapp, Administrator

The Farmer Cooperative Service conducts research studies and service activities of assistance to farmers in connection with cooperatives engaged in marketing farm products, purchasing farm supplies, and supplying business services. The work of the Service relates to problems of management, organization, policies, financing, merchandising, product quality, costs, efficiency, and membership.

The Service publishes the results of such studies; confers and advises with officials of farmer cooperatives; and works with educational agencies, cooperatives, and others in the dissemination of information relating to cooperative principles and practices.

This study was conducted under authority of the Agricultural Marketing Act of 1946 (RMA, Title II).

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Findings

Cottonseed oil mills may be able to increase net revenues substantially by controlling protein level of meal production in the meal grind room rather than in the press room.

Data from six selected screw press mills indicate that protein content of meal production is more uniform when protein reducing hull material is added at the time press cake is ground into meal than when such material is left with cottonseed meats to go through the presses. Of the five mills using press room control, less than half their season's meal production fell within a protein tolerance of 40.5 to 41.5 percent. In contrast, the one mill practicing the more recent meal room control method had 87 percent of its production within the same tolerance.

The effect of shipping cottonseed meal containing more than the guaranteed protein content is a loss in net revenue to the cottonseed producer. For example, if a meal shipment contains 42.5 percent protein and cottonseed meal sells for $60 a ton, the loss in revenue is $1.97 per ton of meal produced or 89 cents per ton of seed. As the price of meal or excess protein becomes greater, inadequate protein control has an increasingly adverse effect on returns to processors.

Calculated losses in revenue from shipping excess protein at the one mill using meal room control was only 8.1 cents per ton of seed crushed as compared with a range of 21.3 to 40.0 cents at mills using press room control.

Other possible advantages of meal room control over press room control include greater oil extraction efficiency, increased press capacity, and lower press power and maintenance costs.

Although this report is based on data obtained from screw press mills, the meal room protein control method should be equally advantageous to solvent and hydraulic mills.

Controlling Protein Level of Meal Production at Cottonseed Oil Mills

by Elmer J. Perdue and J. Dale Peier[1]

Inadequate control on the protein level of cottonseed meal production puts processors at an economic disadvantage with cottonseed meal sales. Most State feed laws require sellers of cottonseed meal to guarantee the protein content of meal shipments. If a meal shipment does not meet its guarantee, it is subject to rejection or a purchase discount, and in some cases the seller may be subject to litigation. Conversely, if a meal shipment contains more than the guaranteed amount of protein, the seller normally does not receive additional compensation.

Difficulties encountered in producing meal at a constant guaranteed protein level results from lack of uniformity in cottonseed. Most mills receive seed from numerous cotton-producing areas that vary in soil fertility, climatic conditions, plant variety, and other factors affecting the inherent ammonia or equivalent protein content of seed. Cottonseed crushers thus face the problem of producing a uniform end product from a variable raw material.

Although seed varies widely in ammonia content, pure cottonseed meats, if processed alone, would yield meal of higher protein content than the normal guaranteed 41 percent. Therefore, at some point in the milling process, less valuable cottonseed hull material is added to reduce protein content.

Two basic methods are used in lowering protein content of meal. The oldest and still most widely used practice is to leave the desired amount of hull material with cottonseed meats at the time of separation. This method is referred to as press control, since control is accomplished by adjusting the amount of hull material allowed to remain with meats as they go through the presses.

The other method is meal or grind room control. This method strives for a reasonably complete separation of meats and hulls. After this separation, pure meats only are put through the press. Protein content is then lowered by adding the desired amount of hull material at the time press cake is being ground into meal.

The primary purpose of this report is to compare these two control practices

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[1] Mr. Perdue is with the Cotton Branch, Marketing Division, Farmer Cooperative Service. Mr. Peier is now with the Agricultural Economics Division, Agricultural Marketing Service, but was in the Marketing Economics Research Division when he was working on this report.

Note: The authors wish to express appreciation to the six mills that supplied information for this study.

as they relate to maintaining uniformity of meal production. Other phases of processing operations such as oil extraction, efficiency, crushing capacity, press power, and press maintenance costs are also considered.

Use is made of information obtained from case studies of six screw press mills during the 1958-59 crushing season. Mill I practices meal room protein control, whereas Mills II through VI practice the more widely used press room control method.

Effectiveness of Protein Control Methods

Effective protein control for purposes of this report is defined as keeping meal production within a range of one-half protein unit above and below the guaranteed protein content of meal shipments.[2] Since all six mills guaranteed 41 percent protein, the effective control range as used here is 40.5 - 41.5 percent.

The most commonly used measure to determine effectiveness of control practices is the season's average protein content of meal production. Table 1 gives the difference between the season's average and the guaranteed 41 percent. It shows that the average fell well within the effective range at all mills except Mill V.

The season's average, however, is not a good measure of effectiveness of protein control methods. First, each meal shipment must stand alone in regard to meeting its guaranteed protein content; and second, in striving for 41 percent, chances are that day-by-day variation above and below 41 percent will about equal each other and average out. For example, a mill may produce one-half of its meal at 40 percent protein and the other half at 42 percent and realize a 41 percent average for the season. Similarly, equal production at 39 and 43 percent protein will also average the desired 41 percent.

To get a true picture of variation of protein content of meal production, a mill can use a frequency distribution. Such a distribution for the six study mills points up a wide variation of protein

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[2] Based on protein deficiency tolerance as set out in Rule 271, "Trading Rules," National Cottonseed Products Association, Memphis, Tenn.

Table 1. - *Season average and guaranteed protein content of cottonseed meal for six selected screw press mills, 1958-59 season*[1]

Mill	Protein content of meal production		
	Season average	Guaranteed level	Difference
		Percent	
I	40.91	41.00	-0.09
II	41.01	41.00	.01
III	41.18	41.00	.18
IV	40.84	41.00	-.16
V	40.08	41.00	-.92
VI	41.33	41.00	.33

[1] Based on daily grind room samples.

Table 2. - *Protein content of cottonseed meal production, six selected screw-press mills, 1958-59 season*[1]

Percent protein	Percent of total production					
	Mill I	Mill II	Mill III	Mill IV	Mill V	Mill VI
	Percent					
Below 39.5	-	3.23	2.77	14.37	22.72	16.71
39.5 - 39.9	-	14.81	1.25	7.64	9.09	6.32
40.0 - 40.4	5.98	17.81	10.47	13.24	40.91	6.39
40.5 - 40.9	44.87	15.50	28.43	16.77	9.09	8.21
41.0	15.89	3.37	9.24	3.95	9.09	2.18
41.1 - 41.5	25.80	18.59	18.63	15.88	4.55	10.08
41.6 - 42.0	7.46	11.58	11.94	9.20	-	11.97
42.1 - 42.5	-	7.47	12.43	4.07	-	9.42
Above 42.5	-	7.64	4.84	14.88	4.55	28.72
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1] Based on daily grind room samples.

content within individual mills as well as between mills (table 3).

As based on frequency distribution, Mill I had 86.6 percent of the season's meal falling within the effective 40.5 to 41.5 percent protein range. In contrast, the other five mills had considerably less meal within this same range and ranked in the following order: Mill III, 56.3 percent; Mill II, 37.5 percent; Mill IV, 36.6 percent, Mill V, 22.7 percent; and Mill VI, 20.5 percent.

The frequency distribution given in table 2 would provide a very good basis for comparing the effectiveness of different control practices if variability in seed crushed were the same for all mills. However, since fluctuations in seed do affect uniformity of protein content of meal it is first necessary to measure that portion of variation resulting from this source.

One method of measuring the effect of seed variability is to determine the percentage of meal that is expected to fall within the 40.5 - 41.5 percent protein range if there were no day-by-day protein control adjustments.

To determine the maximum percentage of meal that would fall in the 40.5 - 41.5 range with only one protein control setting for the season, it is necessary that this setting be made to produce 41 percent protein meal from seed containing the season's average ammonia content. This is not to say that a mill can or should make only one protein control setting for the season, but is only a method used in this study to measure the effects of seed variability.

By using the above method, the percentage of the season's meal[3] expected to fall within the effective 40.5 - 41.5 range is shown in table 3.

The difference between the percentage of meal expected to fall within the 40.5 - 41.5 percent protein range (table 2)

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[3] The percentage of meal expected to fall in the 40.5 - 41.5 percent protein range is equivalent to percentage of daily production seed samples falling within the ammonia range set out in table 3.

Table 3. - *Ammonia content needed to produce 40.5 - 41.5 percent protein meal, and percent of daily seed samples falling within the range, six selected mills, 1958-59 season*[1]

Mill	Average ammonia content of seed crushed	Range of ammonia content to produce 40.5 - 41.5 percent protein meal[2]	Percent of daily production seed samples falling in range
		Percent	
I	3.73	3.68 - 3.78	63.1
II	3.54	3.50 - 3.58	45.1
III	3.56	3.52 - 3.60	51.8
IV	4.05	4.00 - 4.10	28.6
V	3.81	3.76 - 3.86	47.2
VI	4.13	4.08 - 4.18	43.9

[1] Based on mill protein control adjustment permanently set to produce 41 percent protein meal from seed containing season average ammonia content at each mill.

[2] The pounds of 41 percent protein meal derived from a ton of seed containing the season's average ammonia content was found by this formula:

$$\text{Pounds of 41 percent meal} = \frac{\text{percent ammonia in seed} \times .94 \times 2000}{7.98}$$

Holding the number of pounds constant, the range in ammonia content of seed necessary to yield meal in the range of 40.5 to 41.5 percent protein was calculated by substituting 7.884 and 8.078, respectively, for 7.98 in the above formula.

and the actual (table 2) then becomes the basis for comparing the effectiveness of the two methods of protein control (table 4).

Table 4 shows that Mill I, the only study mill adding hull material after the presses, increased the percentage of meal production falling within the effective range by 23.5 percent over that expected. This result shows considerably greater protein control as compared with results at the other five study mills (figure 1).

Table 4. - *Comparison of actual and expected percentage of meal production falling in 40.5 - 41.5 percent protein range, six selected screw-press mills, 1958-59 season*

Mill	Meal production falling within 40.1 - 41.5 percent protein range		Difference[3]
	Actual[1]	Expected[2]	
		Percent	
I	86.6	63.1	23.5
II	37.5	45.1	-7.6
III	56.3	51.8	4.5
IV	36.6	28.6	8.0
V	22.7	47.2	-24.5
VI	20.5	43.9	-23.4

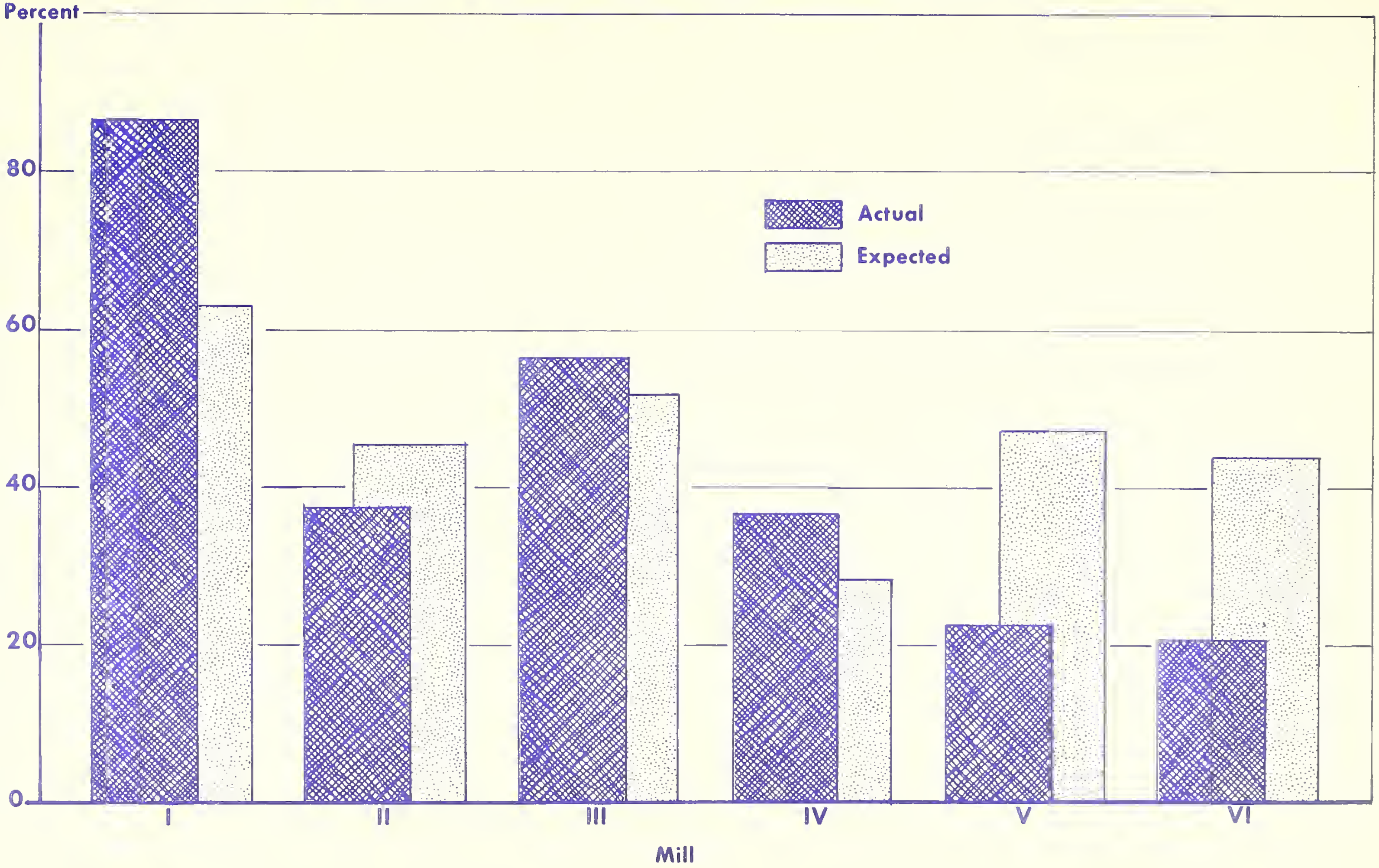
[1] See table 2.

[2] Based on variation of ammonia content of seed crushed in table 3.

[3] The difference between actual and expected percentages of meal production falling in the 40.5 - 41.5 range is the net effect of mill protein control practices.

Figure 1

Comparison of Actual and Expected Percentage of Meal Production Falling in 40.5 - 41.5% Protein Range, Six Selected Screw Press Mills, 1958-59 Season



One important difference between Mill I and the other five mills concerns the use made of sampling to guide the amount of hull material added. Mill I makes use of two press cake bins. Its current cake production is conveyed into one bin while grinding out the second tank that contains cake produced the day before. In this manner, analysis of cake is available before grinding takes place and serves as a guide to the amount of hull material and moisture needed for each specific day's cake production

In the case of the other five mills, press cake or meal grind room samples are necessarily analyzed after hulls have been added. Thus, present work is always based on samples from the previous day's crush, and control adjustments are effective only to the extent that ammonia content of seed and press room operating conditions are the same, or nearly the same, as those of the previous day.

Since it becomes largely a matter of chance in making adjustments on the basis of the previous day's sampling, the negative results shown for Mills II, V, and VI are understandable (figure 1).

Effect on Net Revenue from Excess Protein

Net returns to the mill decrease when meal shipments contain protein content in excess of the guaranteed amount. These losses become greater as excess protein and meal prices increase (figure 2). For example, when meal contains 43 percent protein and sells on a guaranteed 41 percent basis, net loss per ton of meal shipped amounts to $1.58 when meal sells at $40. The loss on this same protein overage increases to $3.16 if meal price is as high as $70.

The losses in net revenue per ton of meal produced shown in figure 2 can be converted to losses per ton of seed crushed by multiplying meal yield per ton of seed crushed by protein loss per ton of meal produced and then dividing by 2,000 pounds.[4]

For example, at a meal yield of 900 pounds, the loss per ton of seed crushed is 71 cents when the loss per ton of meal produced is $1.58; and is $1.42 when meal loss is $3.16 per ton.

Mill I, the only study mill adding hull material in the meal room, had as little as 8.1 cents loss in net revenue per ton of seed crushed as contrasted with 21.3 cents for Mill II, 22.8 cents for Mill III, 23.4 cents for Mill IV, and 40 cents for Mill VI (figure 3). This comparison of losses due to shipping excess protein emphasizes the economic advantage of meal room control over press room control.

The losses in net revenue shown in figure 3 result from shipping excess protein only; it does not take into account any losses due to shipping meal of less than the guaranteed protein content. Hence, actual losses from inadequate protein control may be even greater than those shown here.

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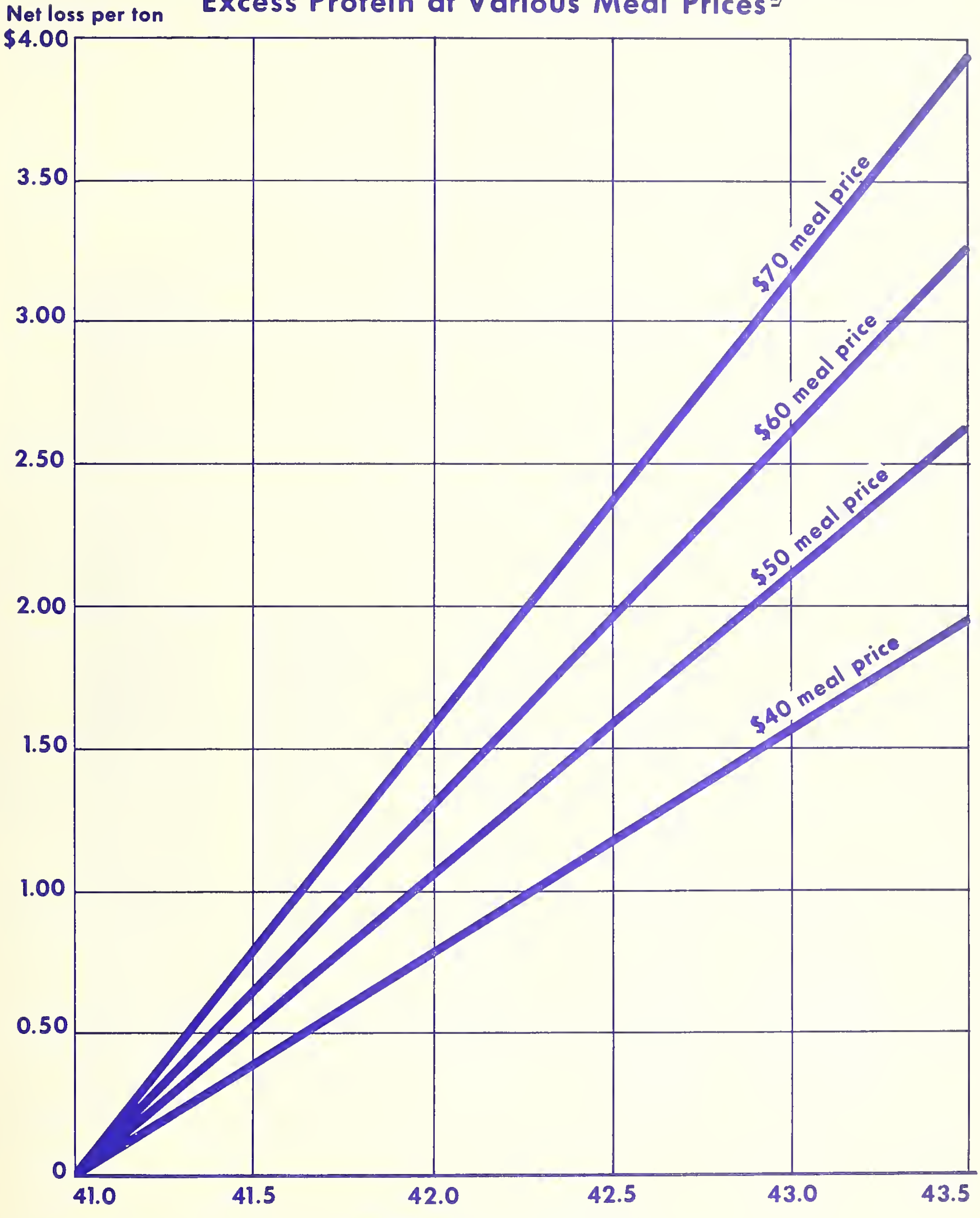
[4] $$\frac{\text{Revenue loss per ton of meal from excess protein} \times \text{Pounds of meal per ton of cottonseed}}{2{,}000 \text{ pounds}} = \text{Revenue loss per ton of seed from which meal in excess of 41 percent protein is produced}$$

Figure 2

Revenue Loss in Selling Cottonseed Meal Containing Excess Protein at Various Meal Prices[1]

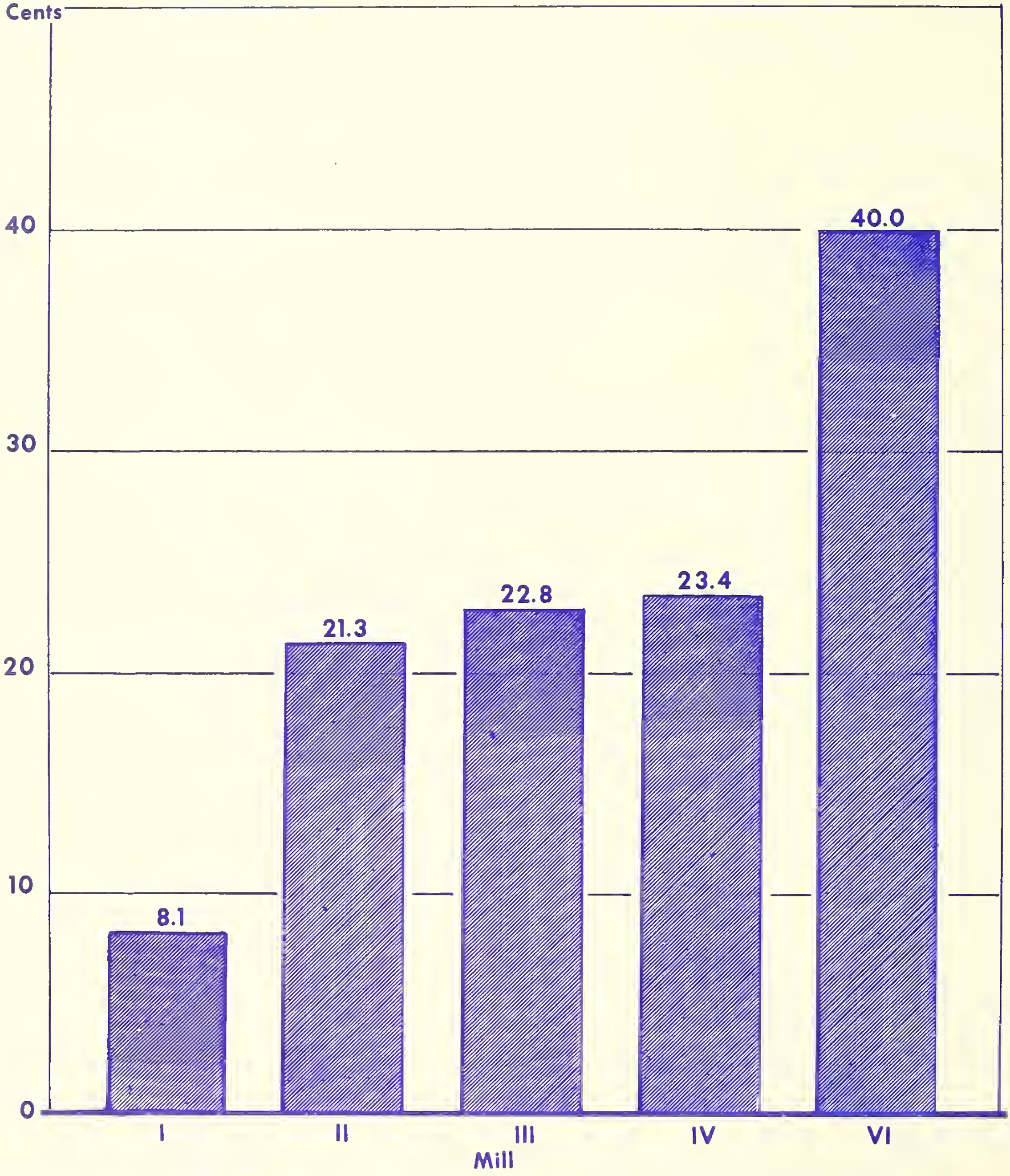


Percentage of Protein in Meal

[1] *Based on hulls with 3 percent protein content at $10 per ton.*

Figure 3

Revenue Loss on Sales of Cottonseed Meal of Excess Protein, per Ton of Seed Crushed, 5 Selected Screw Press Mills, 1958-59[1]



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[1] This chart assumes 900 pounds meal yield, a meal price of $60 per ton, hulls at $10 per ton, and a protein frequency distribution of meal shipments the same as the meal grind room sample distribution given in table 2. Mill V is omitted because its meal was below the 41 percent level.

Effects of Protein Control Methods on Overall Milling Efficiency

Cottonseed crushers must evaluate different milling practices in light of overall milling efficiency. In the preceding section the two basically different methods of adding hull material, before versus after the presses, were examined in respect to meal protein control. In this section further analysis of these two methods is made in respect to other phases of the milling process.

Oil Extraction

The amount of oil retained in press cake is usually considered to be the most important single measure of extraction efficiency. Each 1 percent oil in cake or meal from a ton of seed yielding 800 to 1,000 pounds of 41 percent cake represents 8 to 10 pounds of unrecovered oil, whereas the oil remaining in hulls, lint, and sweepings normally accounts for only 3 to 4 pounds per ton of seed crushed.

The season's average oil, protein, and moisture contents of press cake samples for the six study mills are shown in table 5. The oil content in press cake at Mill I was only 3.27 percent as compared with higher oil content at all other mills with the exception of Mill II which left 3.02 percent. The important point brought out by this comparison is that a low oil content in press cake was obtained by Mill I which used meal room protein control.

Press cake samples for each mill were analyzed to find if any relationship existed between oil and protein content. This analysis showed that there was no apparent relationship between these two variables. This same conclusion was reached by Wamble and Harris.[5]

Although the method of adding hull material does not affect the percentage of oil content in cake, it may cause a difference in the total oil left in cake or equivalent meal. This is because hull material with remaining lint will tend to absorb oil during pressing.[6] The amount

Table 5. - *Chemical analysis of press cake, actual and 8 percent moisture basis, six selected screw-press mills, 1958-59 season*

Mill	Chemical analysis				
	Actual			8 percent moisture basis	
	Oil	Protein	Moisture	Oil	Protein
	Percent				
I	3.44	46.10	3.09	3.27	43.84
II	3.21	44.60	2.07	3.02	41.95
III	4.13	43.21	2.33	3.90	40.76
IV	3.94	43.98	3.00	3.74	41.78
V	4.33	41.17	4.82	4.19	39.86
VI	3.70	43.16	3.44	3.53	41.19

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[5] Wamble, A. Cecil, and Harris, William B., Screw Pressing of Cottonseed. Bulletin 136, Sept. 1954, Texas Engineering Experiment Station, College Station, Texas, p. 20.

[6] Absorption of oil by hull material going through the presses is probably due largely to the lint remaining on hulls rather than to hulls themselves.

of oil absorbed by hulls when going through the presses will depend on the oil content of the hull material itself, the amount of hulls added, and the oil content in press cake.

For example, Mill I added hulls after the presses and produced cake containing 43.84 percent protein and 3.27 percent oil (table 5). Based on seed yielding 900 pounds of 41 percent protein meal, Mill I put only 842 pounds of meats through the presses and added 58 pounds hull material in the meal room. Multiplying 842 pounds of cake by 3.27 (the percentage oil in cake) and 58 pounds of hulls by an estimated 0.5 percent oil gives a total of 27.8 pounds of oil left in meal. However, if hulls are added before the presses, 900 pounds of cake at 3.27 percent oil gives a total of 29.4 pounds of oil remaining in meal. Thus, by adding 58 pounds hull material in the meal room rather than before the presses, Mill I increased oil extraction by the difference between 29.4 and 27.8 pounds of oil. This is a saving of 1.6 pounds of oil per ton of seed crushed.

Assuming that the other five mills which used press room control had crushed seed comparable to that processed at Mill I, greater oil extraction efficiency would have resulted in the following increases: Mill II, 1.5 pounds; Mill III, 2 pounds; Mill IV, 1.9 pounds; Mill V, 2.1 pounds, and Mill VI, 1.8 pounds. At an oil price of 10 cents a pound, losses in revenue resulting from adding hulls before the presses ranges from 15 to 21 cents per ton of seed crushed.

Press Capacity

Press capacity as measured by the tonnage of cottonseed that can be put through a press in a given time is affected by many operating variables. Based on a series of controlled experiments Wamble and Harris[7] made several recommendations for increasing press throughput. Among those recommended operating procedures was that of processing as high a protein cake as possible.

Given the same operating conditions and type of seed, mill room control (processing high protein cake) results

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[7] Wamble, A. Cecil, and Harris, William B., Screw Pressing of Cottonseed. Bulletin 136, Sept. 1954, Texas Engineering Experiment Station, College Station, Texas, pp. 68-69.

Table 6. - *Calculated percentage increase in press capacity as related to increase in protein content of press cake*[1]

Protein content of press cake	Material per ton of seed going through presses	Hull material added to press in meal room[2]	Increase in press capacity
Percent	*Pounds*	*Pounds*	*Percent*
41	900	0	0
42	878	22	2.50
43	858	42	4.90
44	838	62	7.40
45	820	80	9.75

[1] Based on seed yielding 900 pounds of 41 percent protein meal per ton cottonseed.
[2] No allowance made for protein content of hulls, which normally runs about 3 percent.

in increased throughput because less bulk per ton of seed goes through the presses.

Assuming that seed yields 900 pounds of 41 percent protein meal, press capacity is increased approximately 2.5 percent for each 1 percent increase in protein content of cake coming from the presses (table 6). For example, a mill crushing 100 tons of seed daily could increase crushing capacity to 109.75 tons by increasing protein content of press cake from 41 to 45 percent.

Press Power and Maintenance Costs

Press power and press maintenance costs are affected by many variables. However, with the same type of seed and operating conditions, it is reasonable to expect that press power and press maintenance costs will decrease proportionally to the decrease in amount of material put through the presses.

Although the meal room protein control method involves grinding of hulls into hull bran, the additional power requirement is relatively small as compared to the power required to put the same amount of hull through the presses.

Much wear of screw presses comes from dirt and other abrasive material not removed in the cleaning process. Hulls and hull particles with remaining lint are primary sources of such abrasive material and it is reasonable to assume that mills which practice cutting protein in the meal room would realize a reduction in press maintenance cost over and beyond that associated with putting less material through the presses.